East Asian VLBI Network observations of nearby supermassive black holes SgrA* and M87

APRIM2017, 3-7 Jul 2017, Taipei

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On behalf of

EAVN Commissioning Team (The "Tiger Team")

EAVN AGN Science Working Group

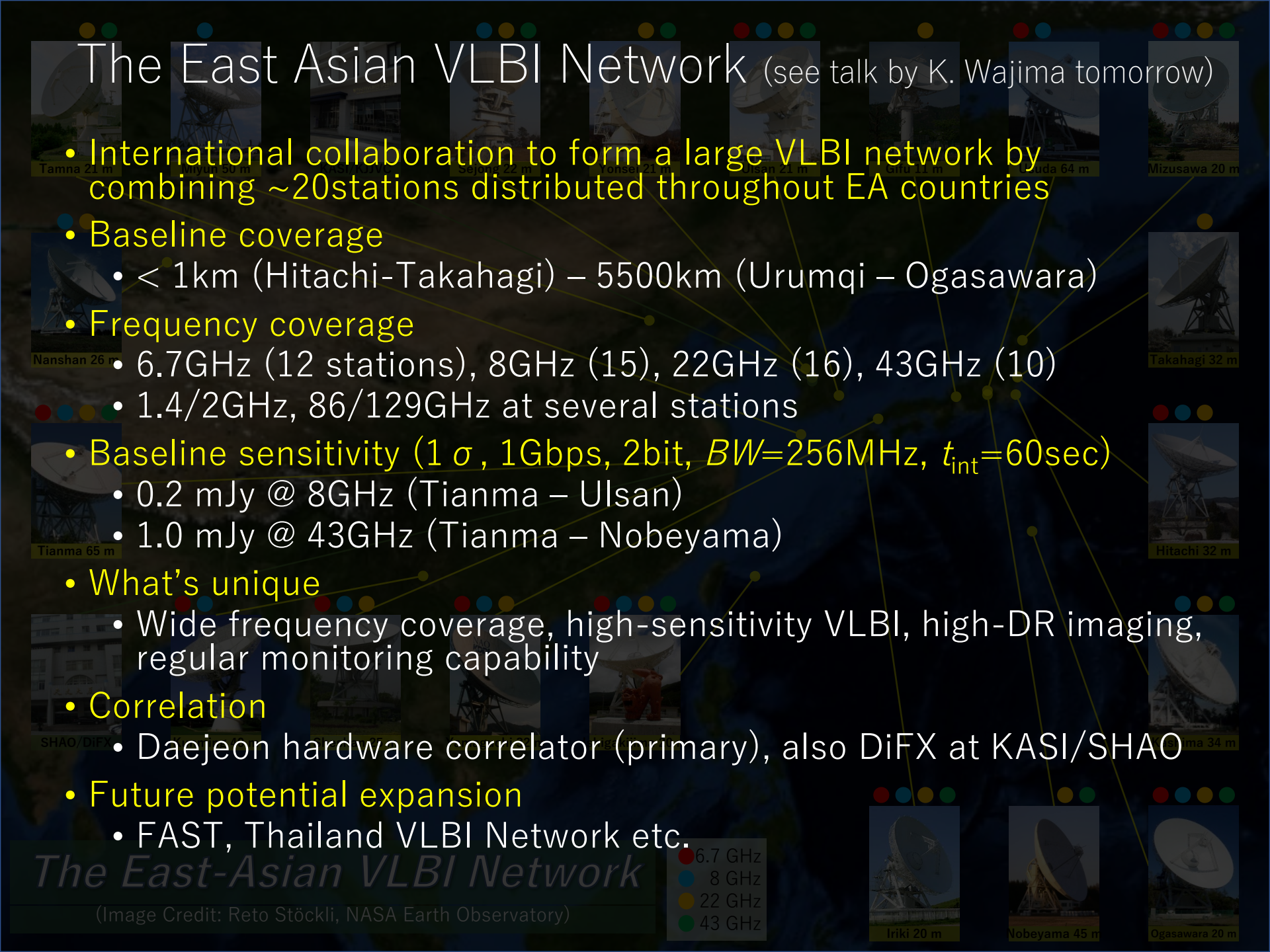
Outline

- The East Asian VLBI Network (EAVN)
- EAVN campaign observations of SgrA/M87 in spring 2017
- Very early progress report


Tamna 21 m
Miyun 50 m
Sejong 22 m
Yonsei 21 m
Ulsan 21 m
Gifu 11 m
Usuda 64 m
Mizusawa 20 m
Nanshan 26 m
Takahagi 32 m
CVN
KVN
VERA
JVN
Tianma 65 m
Hitachi 32 m
Kunming 40 m
Sheshan 25 m
Yamaguchi 32 m
shigakijima 20 m
Kashima 34 m
Iriki 20 m
Nobeyama 45 m
Ogasawara 20 m
The East-Asian VLBI Network
(Image Credit: Reto Stöckli, NASA Earth Observatory)
6.7 GHz
8 GHz
22 GHz
43 GHz

The East Asian VLBI Network (see talk by K. Wajima tomorrow)

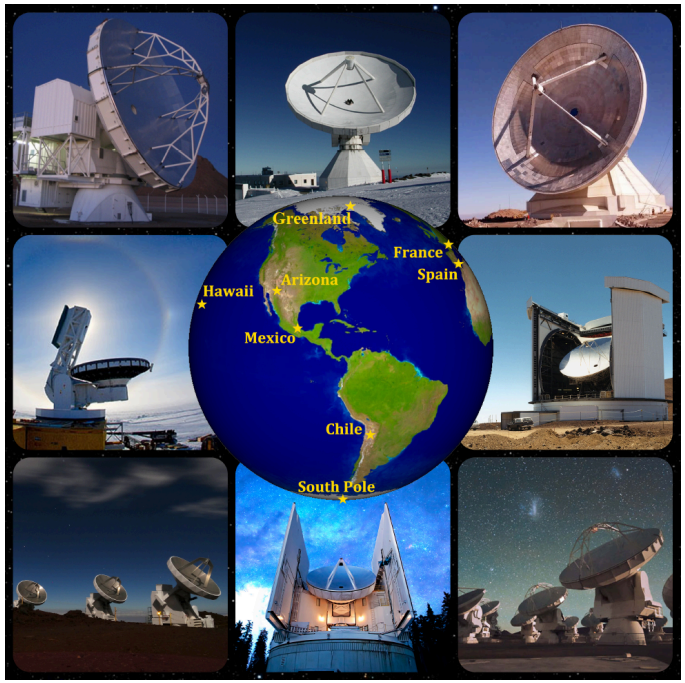
- International collaboration to form a large VLBI network by combining ~20stations distributed throughout EA countries
- Baseline coverage
  - < 1km (Hitachi-Takahagi) – 5500km (Urumqi – Ogasawara)
- Frequency coverage
  - 6.7GHz (12 stations), 8GHz (15), 22GHz (16), 43GHz (10)
  - 1.4/2GHz, 86/129GHz at several stations
- Baseline sensitivity (1 σ, 1Gbps, 2bit, BW=256MHz, t_{int}=60sec)
  - 0.2 mJy @ 8GHz (Tianma – Ulsan)
  - 1.0 mJy @ 43GHz (Tianma – Nobeyama)
- What's unique
  - Wide frequency coverage, high-sensitivity VLBI, high-DR imaging, regular monitoring capability
- Correlation
  - Daejeon hardware correlator (primary), also DiFX at KASI/SHAO
- Future potential expansion
  - FAST, Thailand VLBI Network etc.

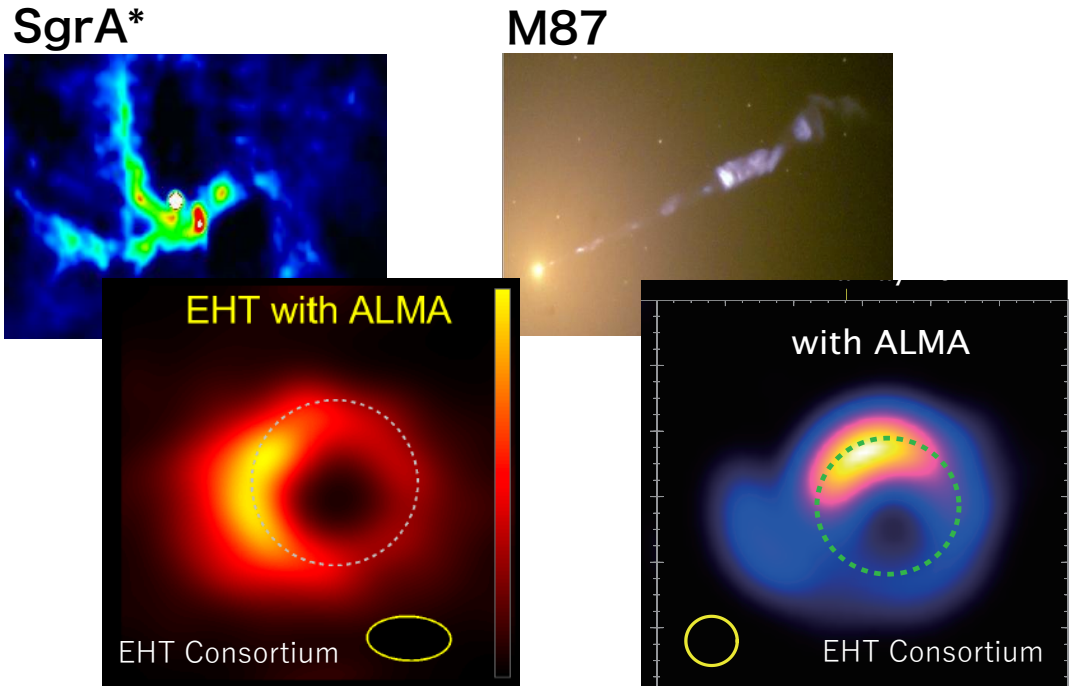


EAVN status and timeline

- **2013**
  - Formed Korea-Japan-China joint EAVN commissioning team
- **2014-2015**
  - Fringe tests with a small number of stations
  - (meanwhile, regular operation of KVN+VERA (KaVA) started)
- **2016**
  - Promoted commissioning with more stations, array performance evaluation
  - First imaging test observations with KaVA+Tianma65m
- **2017**
  - Validate array performance for 1st open-use cycle
- **(Early-)2018**
  - Start open-use operation with a subset of EAVN stations (e.g., KaVA+Tianma), mainly 22/43GHz? (not fixed yet)

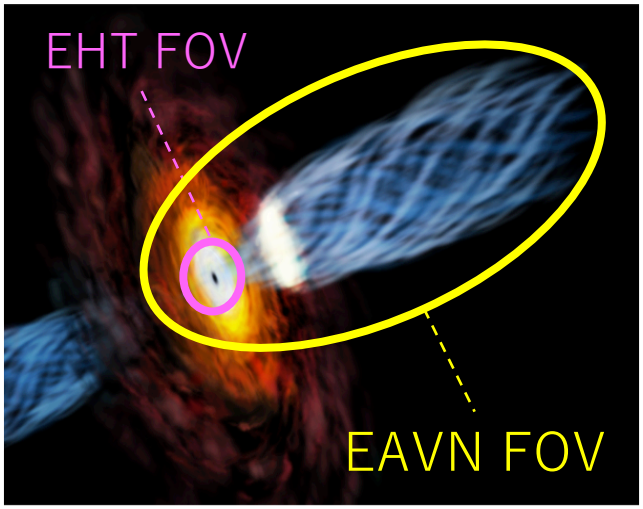
SgrA* and M87: the nearest SMBH





- Event Horizon Telescope in April 2017
- BH shadows in SgrA* & M87
- Accretion flow, jet launching

- EHT - limited FOV, limited image quality
- Complementary low frequency, high-quality VLBI data crucial => **EAVN**



EAVN campaign in spring 2017

- **Commissioning purpose**
  - Promote EAVN test observations. Rehearsal of regular operation
- **Scientific purpose**
  - Complement EHT. Demonstration of EAVN science capability

	Date	UT time	Target	Freq.	Stations
1	3/12	18:55 – 00:55 (6hr)	SgrA	43GHz	KaVA7, TM
2	3/18	12:45 – 19:45 (7hr)	M87	22GHz	KaVA7, TM, UR, HT, KS
3	3/19	11:40 – 18:40 (7hr)	M87	43GHz	KaVA7, TM
4	3/27	13:10 – 23:10 (10hr)	M87+SgrA	43GHz	KaVA7, TM
5	4/3	13:20 – 23:20 (10hr)	M87+SgrA	22GHz	KaVA7, TM, UR, HT, KS, MC
6	4/4	12:35 – 22:40 (10hr)	M87+SgrA	43GHz	KaVA7, TM
7	4/9	12:20 – 22:20 (10hr)	M87+SgrA	43GHz	KaVA7, TM, NY
8	4/14	12:00 – 22:00 (10hr)	M87+SgrA	43GHz	KaVA7, TM
9	4/17	11:45 – 18:45 (10hr)	M87	22GHz	KaVA7, TM, UR, HT, KS, SJ, MC, NT
10	4/18	11:40 – 21:45 (10hr)	M87+SgrA	43GHz	KaVA7, TM
11	4/24	09:20 – 16:20 (7hr)	M87	22GHz	KaVA7, TM
12	4/25	09:15 – 16:15 (7hr)	M87	43GHz	KaVA7, TM
13	4/26	15:55 – 21:55 (6hr)	SgrA	43GHz	KaVA7, TM, SJ
14	5/10	08:20 – 17:20 (7hr)	M87	22GHz	KaVA7, TM, MC
15	5/11	08:15 – 17:15 (7hr)	M87	43GHz	KaVA7, TM
16	5/25	14:00 – 20:00 (6hr)	SgrA	43GHz	KaVA7, TM
17	5/26	07:15 – 16:15 (7hr)	M87	43GHz	KaVA7, TM

EHT period

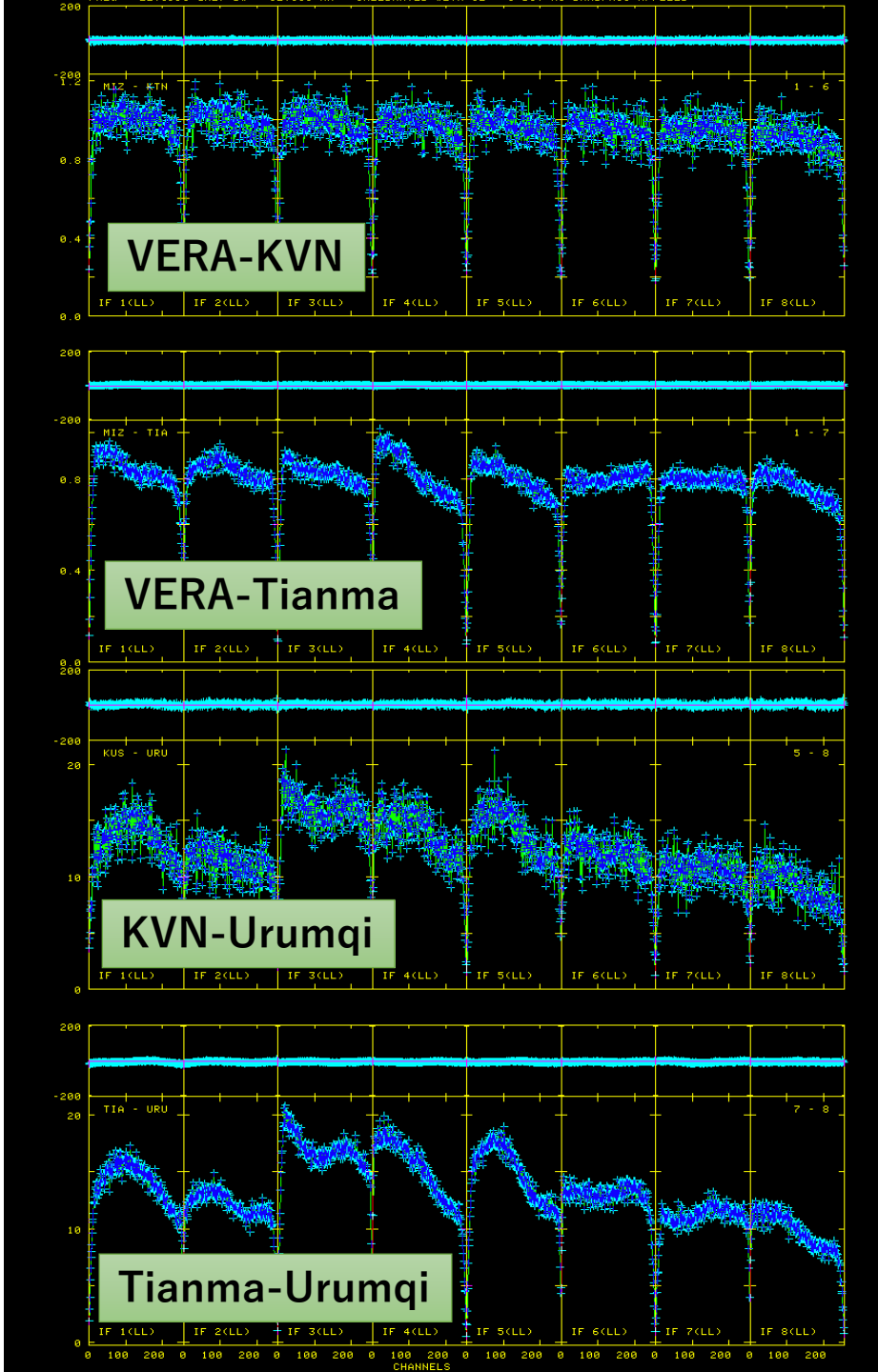
- **17 epochs (5 @ 22GHz, 12 @ 43GHz)**
- **140hr (40 @ 22GHz, 100 @ 43GHz)**
- **KaVA+Tianma for all the epochs**

TM: Tianma, UR: Urumqi,
SJ: Sejong, HT: Hitachi,
KS: Kashima, NY: NRO45,
MC: Medicina, NT: Noto

EAVN fringes

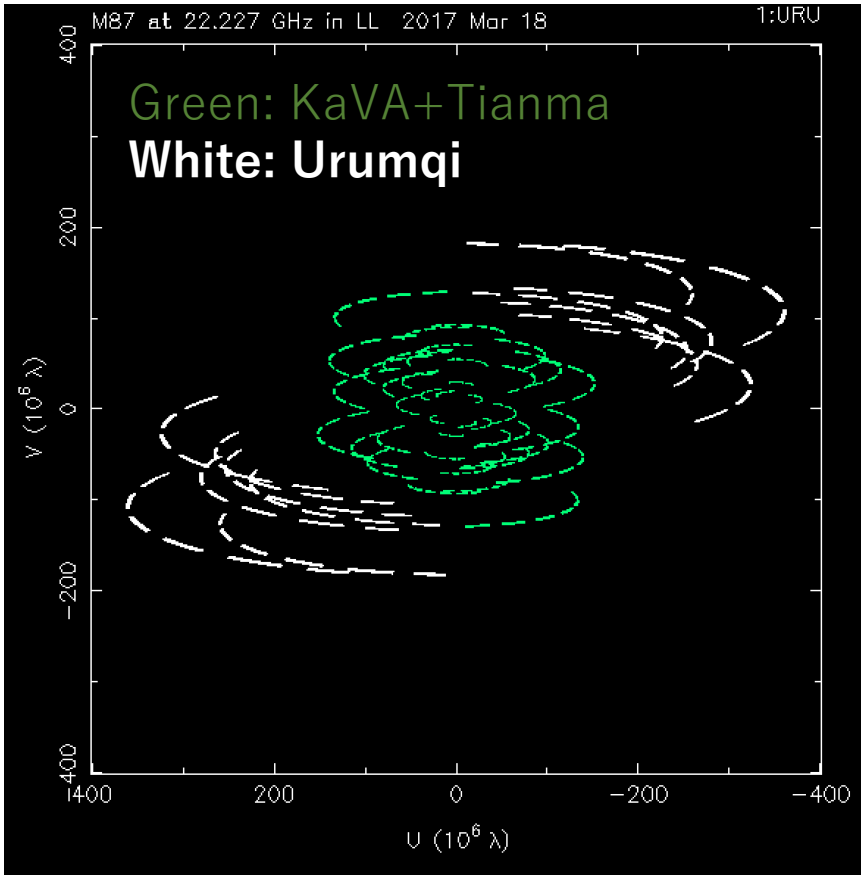
- Correlation and data analysis in progress
- Correlation finished for 7 epochs
- KaVA+Tianma fringes detected for most of these epochs

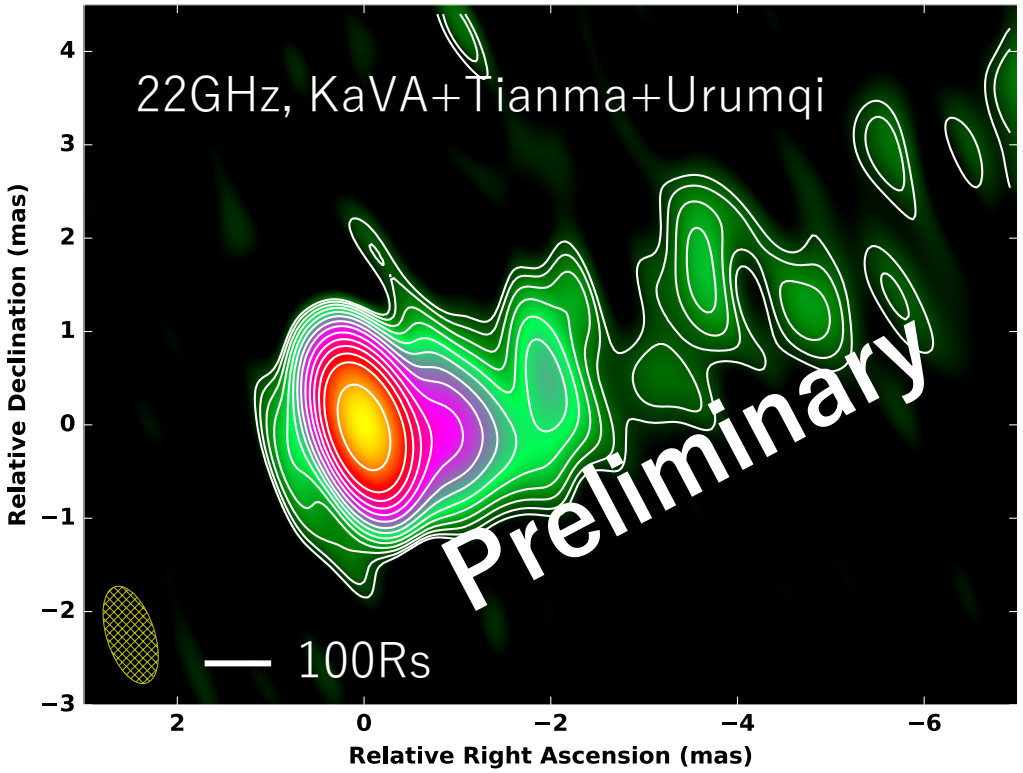
- March/18/2017 (22GHz)
- First complete EAVN fringes among VERA, KVN, Tianma and Urumqi



M87

- March/18/2017, 22GHz
- KaVA, Tianma, Urumqi (Hitachi and Kashima remain to be added)



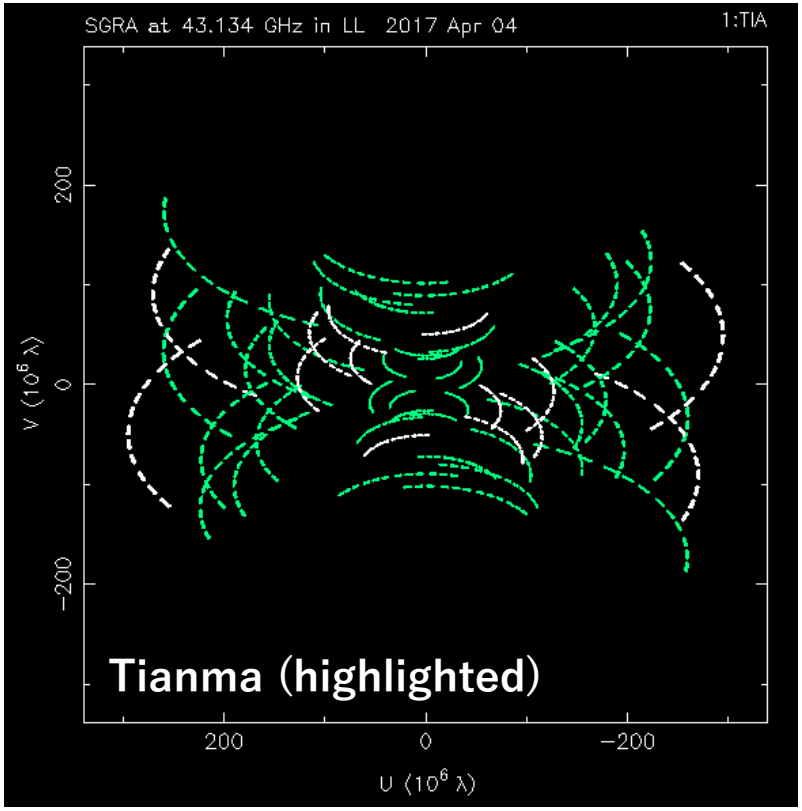


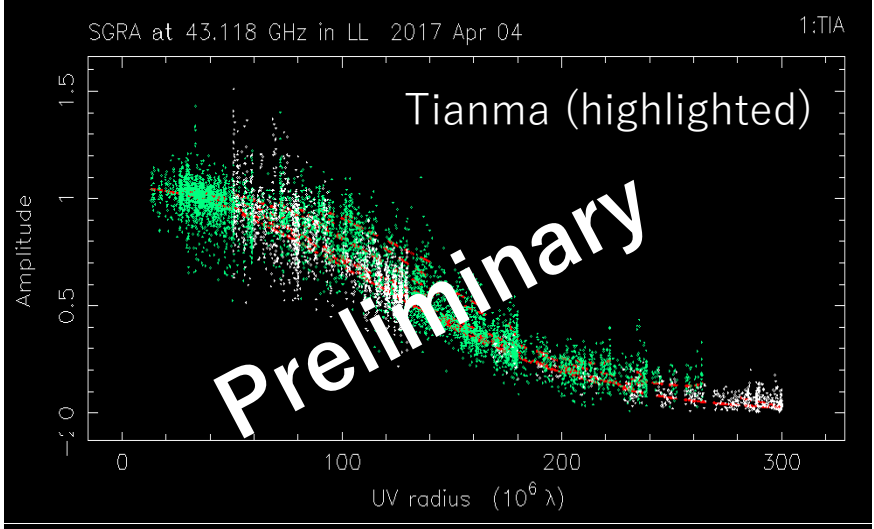
- First EAVN image with 5500km baselines!
- 0.5mas E-W at 22GHz (2.5 times better than KaVA beam)

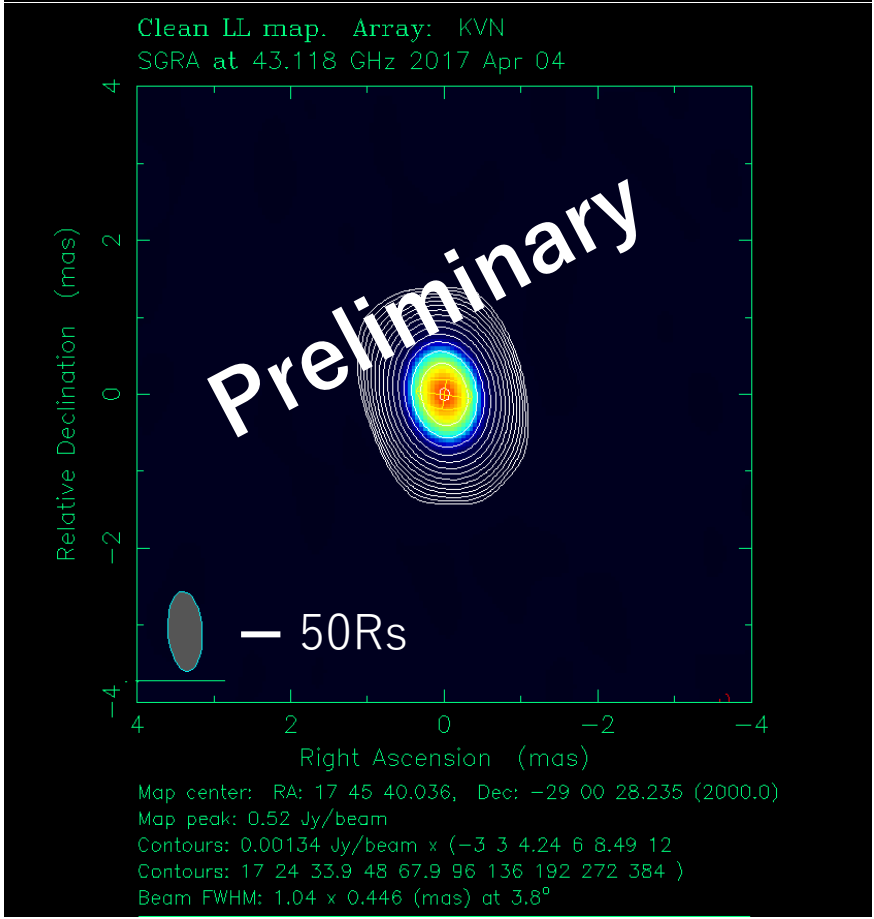
SgrA*

- April/4/2017, 43GHz
- KaVA + Tianma

Visit P4-02 by Guangyao Zhao







- First KaVA+Tianma image on SgrA*
- Tianma improved uv-coverage & resolution, and ~doubled image dynamic range

Summary

- The East Asian VLBI collaboration is now rapidly growing
- EAVN campaign observations of SgrA*/M87 in concert with EHT
  - Accelerate EAVN commissioning
  - Demonstrate a good science case
- Correlation and data analysis still on the way, but we already had some important progress
  - First successful fringes among VERA, KVN, Tianma and Urumqi
  - First successful image with 5500km baselines
  - Significant array performance enhancement with Tianma
- Powerful science indeed promising with EAVN!